# NATIONAL ENTRANCE SCREENING TEST
# 2026

# NEST 2026

# SYLLABUS

Entrance test for admission to

**5-year Integrated MSc Programme, 2026-31**

at

**National Institute of Science Education and Research (NISER), Bhubaneswar**

and

**University of Mumbai - Department of Atomic Energy Centre for Excellence in Basic Sciences (UM-DAE CEBS), Mumbai**

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## CLASS XI - THEORY

| Unit | Title |
|---|---|
| I | Diversity of Living Organisms |
| II | Structural Organization in Plants and Animals |
| III | Cell: Structure and Function |
| IV | Plant Physiology |
| V | Human Physiology |

**Unit-I Diversity of Living Organisms**

**1: The Living World**

Biodiversity; Need for classification; three domains of life; taxonomy and systematics; concept of species and taxonomical hierarchy; binomial nomenclature

**2: Biological Classification**

Five kingdom classification; Salient features and classification of Monera, Protista and Fungi into major groups; Lichens, Viruses and Viroids.

**3: Plant Kingdom**

Classification of plants into major groups; Salient and distinguishing features and a few examples of Algae, Bryophyta, Pteridophyta, Gymnospermae and Angiosperms.

**4: Animal Kingdom**

Salient features and classification of animals, non-chordates up to phyla level and chordates upto class level (salient features and a few examples of each category).

**Unit-II Structural Organization in Plants and Animals**

**5: Morphology of Flowering Plants**

Morphology of different parts of flowering plants: root, stem, leaf, inflorescence, flower, fruit and seed. Semi-technical description of a typical flowering plant. Description of family Solanaceae

**6: Anatomy of Flowering Plants**

Anatomy and functions of tissue systems in dicots and monocots.

### 7: Structural Organisation in Animals

Morphology, Anatomy and functions of different systems (digestive, circulatory, respiratory, nervous and reproductive) of frog.

## Unit-III Cell: Structure and Function

### 8: Cell-The Unit of Life

Cell theory and cell as the basic unit of life, structure of prokaryotic and eukaryotic cells; Plant cell and animal cell; cell envelope; cell membrane, cell wall; cell organelles - structure and function; endomembrane system, endoplasmic reticulum, golgi bodies, lysosomes, vacuoles, mitochondria, ribosomes, plastids, microbodies; cytoskeleton, cilia, flagella, centrosomes and centrioles; nucleus.

### 9: Biomolecules

Chemical constituents of living cells: metabolites, biomolecules, structure and function of proteins, carbohydrates, lipids, and nucleic acids; Enzyme - types, properties, enzyme action.

### 10: Cell Cycle and Cell Division

Cell cycle, mitosis, meiosis and their significance.

## Unit-IV Plant Physiology

### 11: Photosynthesis in Higher Plants

Photosynthesis as a means of autotrophic nutrition; site of photosynthesis, pigments involved in photosynthesis; photochemical and biosynthetic phases of photosynthesis; the electron transport chain and use of ATP and NADPH; cyclic and non-cyclic photophosphorylation; chemiosmotic hypothesis; photorespiration; C3 and C4 pathways; factors affecting photosynthesis.

### 12: Respiration in Plants

Exchange of gases; cellular respiration - glycolysis, fermentation (anaerobic), TCA cycle, electron transport system and oxidative phosphorylation (aerobic); energy relations – respiratory balance sheet and number of ATP molecules generated; amphibolic pathways; respiratory quotient.

### 13: Plant - Growth and Development

Seed germination; phases of plant growth and plant growth rate; conditions of growth; differentiation, dedifferentiation and redifferentiation; sequence of developmental processes in a plant cell; plant growth regulators - auxin, gibberellin, cytokinin, ethylene, abscisic acid (ABA).

**Unit-V Human Physiology**

**14: Breathing and Exchange of Gases**

Respiratory organs in animals; Respiratory system in humans; mechanism of breathing and its regulation in humans - exchange of gases, transport of gases and regulation of respiration, respiratory volume; disorders related to respiration - asthma, emphysema, occupational respiratory disorders.

**15: Body Fluids and Circulation**

Composition of blood, blood groups, coagulation of blood; composition of lymph and its function; human circulatory system - Structure of human heart and blood vessels; cardiac cycle, cardiac output, ECG; double circulation; regulation of cardiac activity; disorders of circulatory system - hypertension, coronary artery disease, angina pectoris, heart failure.

**16: Digestion and Absorption**

Alimentary canal and digestive glands, role of digestive enzymes and gastrointestinal hormones; Peristalsis, digestion, absorption and assimilation of proteins, carbohydrates and fats; calorific values of proteins, carbohydrates and fats; egestion; nutritional and digestive disorders - PEM, indigestion, constipation, vomiting, jaundice, diarrhoea.

**17: Excretory Products and their Elimination**

Modes of excretion - ammonotelism, ureotelism, uricotelism; human excretory system – structure and function; urine formation, function of tubules, mechanism of concentration of filtrate, osmoregulation; regulation of kidney function - renin - angiotensin, atrial natriuretic factor, micturition, ADH and diabetes insipidus; role of other organs in excretion; disorders - uremia, renal failure, renal calculi, glomerulonephritis; dialysis and artificial kidney, kidney transplant.

**18: Locomotion and Movement**

Types of movement – amoeboid, ciliary, flagellar, muscular; muscle - skeletal muscle, visceral and smooth muscles, cardiac muscles, contractile proteins and muscle contraction; skeletal system and its functions; joints; disorders of muscular and skeletal systems - myasthenia gravis, tetany, muscular dystrophy, arthritis, osteoporosis, gout.

**19: Neural Control and Coordination**

Neuron and nerves; Nervous system in humans - central nervous system; peripheral nervous system and visceral nervous system; neural system – structure and function of neurons, generation and conduction of nerve impulse, transmission of impulse, central neural system.

**20: Chemical Coordination and Integration**

Endocrine glands and hormones; human endocrine system - hypothalamus, pituitary, pineal, thyroid, parathyroid, adrenal, pancreas, gonads; harmones of heart, kidney and gastrointestinal system; mechanism of hormone action; role of hormones as messengers and regulators, hypo - and hyperactivity and related disorders; dwarfism, acromegaly, cretinism, goiter, exophthalmic goitre, diabetes, Addison's disease.

## CLASS XII - THEORY

| Unit | Title |
|------|-------|
| VI | Reproduction |
| VII | Genetics and Evolution |
| VIII | Biology and Human Welfare |
| IX | Biotechnology and its Applications |
| X | Ecology and Environment |

**Unit-VI Reproduction**

**1: Sexual Reproduction in Flowering Plants**

Flower structure; structure and development of male and female gametophytes; pollination - types, agencies and examples; out breeding devices; pollen-pistil interaction; double fertilization; post fertilization events – structure and development of endosperm and embryo, development of seed and formation of fruit; special modes- apomixis, parthenocarpy, polyembryony; Significance of seed dispersal and fruit formation.

**2: Human Reproduction**

Male and female reproductive systems; microscopic anatomy of testis and ovary; gametogenesis -spermatogenesis and oogenesis; menstrual cycle; fertilisation, embryo development upto blastocyst formation, implantation; pregnancy and placenta formation; parturition; lactation.

**3: Reproductive Health**

Need for reproductive health – problems and strategies, Sexually Transmitted Diseases (STDs) or infections and their prevention; population stabilisation and birth control - need and methods, contraception and medical termination of pregnancy (MTP); amniocentesis; infertility and assisted reproductive technologies - IVF, ZIFT, IUT, GIFT, ICSI, AI, IUI (elementary idea for general awareness).

**Unit-VII Genetics and Evolution**

**4: Principles of Inheritance and Variation**

**Heredity and variation:** Mendelian inheritance; laws of inheritance - law of dominance and law of segregation; deviations from Mendelism – incomplete dominance, co-dominance, multiple alleles, inheritance of two genes and inheritance of blood groups, pleiotropy; elementary idea of polygenic inheritance; chromosome theory of inheritance; chromosomes and genes; Sex determination - in humans, birds and honey bee; linkage recombination and crossing over; genetic

disorders – pedigree analysis, Mendelian disorders in humans - sex linked inheritance - haemophilia, colour blindness; sickle-cell anaemia, thalassemia, phenylketonuria; chromosomal disorders in humans; Down's syndrome, Turner's and Klinefelter's syndromes.

## 5: Molecular Basis of Inheritance

DNA - Search for genetic material and DNA as genetic material; RNA world; Structure of DNA and RNA; DNA packaging; DNA replication; Central Dogma; transcription, genetic code, translation; gene expression and regulation - lac operon; Genome, Human and rice genome projects; DNA fingerprinting.

## 6: Evolution

Origin of life; biological evolution and evidences for biological evolution (paleontology, comparative anatomy, embryology and molecular evidences); Darwin's contribution, modern synthetic theory of evolution; mechanism of evolution - variation (mutation and recombination) and natural selection with examples and evolutionary history, types of natural selection; Gene flow and genetic drift; Hardy- Weinberg's principle; adaptive radiation; human evolution.

## Unit-VIII: Biology and Human Welfare

## 7: Human Health and Diseases

Pathogens; parasites causing human diseases (malaria, dengue, chikungunya, filariasis, ascariasis, typhoid, pneumonia, common cold, amoebiasis, ring worm) and their control; Basic concepts of immunology – acquired immunity, active and passive immunity, vaccines and immunisation; Allergies; auto immunity; Immune system and human diseases - cancer, HIV and AIDS; drug and alcohol abuse, Adolescence – addiction and dependence; effects of drug and alcohol abuse, prevention and control.

## 8: Microbes in Human Welfare

Microbes in food processing, industrial production, sewage treatment, energy generation and microbes as bio-control agents and bio-fertilizers. Antibiotics; production and judicious use.

## Unit-IX Biotechnology and its Applications

## 9: Biotechnology - Principles and Processes

Principles, Genetic Engineering (Recombinant DNA Technology) – Tools and processes.

## 10: Biotechnology and its Applications

Application of biotechnology in health and agriculture: Green revolution and tissue culture; Human insulin and vaccine production, stem cell technology, gene therapy; genetically modified organisms – Bt crops; transgenic animals; biosafety and ethical issues, biopiracy and patents.

**Unit-X Ecology and Environment**

**11: Organisms and Populations**

Population interactions - mutualism, competition, predation, parasitism; population attributes - growth, birth rate and death rate, age distribution.

**12: Ecosystem**

Ecosystems: Patterns, components; productivity and decomposition; energy flow; pyramids of number, biomass, energy.

**13: Biodiversity and its Conservation**

Biodiversity-Concept, patterns, importance; loss of biodiversity; biodiversity conservation; hotspots, endangered organisms, extinction, Red Data Book, Sacred Groves, biosphere reserves, national parks, wildlife, sanctuaries and Ramsar sites.

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## CLASS XI - THEORY

| Unit | Title |
|------|-------|
| 1 | Some Basic Concepts of Chemistry |
| 2 | Structure of Atom |
| 3 | Classification of Elements and Periodicity in Properties |
| 4 | Chemical Bonding and Molecular Structure |
| 5 | Chemical Thermodynamics |
| 6 | Equilibrium |
| 7 | Redox Reactions |
| 8 | Organic Chemistry: Some basic Principles and Techniques |
| 9 | Hydrocarbons |

**Unit 1: Some Basic Concepts of Chemistry**

**General Introduction:** Importance and scope of Chemistry, Nature of matter, laws of chemical combination,

**Dalton's atomic theory:** concept of elements, atoms and molecules, atomic and molecular masses, mole concept and molar mass, percentage composition, empirical and molecular formula, chemical reactions, stoichiometry and calculations based on stoichiometry.

**Unit 2: Structure of Atom**

Discovery of Electron, Proton and Neutron, atomic number, isotopes and isobars. Thomson's model and its limitations. Rutherford's model and its limitations, Bohr's model and its limitations, concept of shells and subshells, dual nature of matter and light, de Broglie's relationship, Heisenberg uncertainty principle, concept of orbitals, quantum numbers, shapes of s, p and d orbitals, rules for filling electrons in orbitals - Aufbau principle, Pauli's exclusion principle and Hund's rule, electronic configuration of atoms, stability of half-filled and completely filled orbitals.

**Unit 3: Classification of Elements and Periodicity in Properties**

Significance of classification, brief history of the development of periodic table, modern periodic law and the present form of periodic table, periodic trends in properties of elements -atomic radii,

ionic radii, inert gas radii, Ionization enthalpy, electron gain enthalpy, electronegativity, valiancy, Nomenclature of elements with atomic number greater than 100.

**s & p Block Elements -** Electronic configuration, atomic & Ionic radii, Ionization Enthalpy, Hydration Enthalpy and general trends in physical and chemical properties of s and p block elements across the periods and down the groups; unique behavior of the first element in each group.

### Unit 4: Chemical Bonding and Molecular Structure

Valence electrons, ionic bond, covalent bond, bond parameters, Lewis structure, polar character of covalent bond, covalent character of ionic bond, valence bond theory, resonance, geometry of covalent molecules, VSEPR theory, concept of hybridization, involving s, p and d orbitals and shapes of some simple molecules, molecular orbital theory of homonuclear diatomic molecules (qualitative idea only), Hydrogen bond.

### Unit 5: Chemical Thermodynamics

Concepts of System and types of systems, surroundings, work, heat, energy, extensive and intensive properties, state functions.

**First law of thermodynamics -** internal energy and enthalpy, heat capacity and specific heat, measurement of $\Delta U$ and $\Delta H$, Hess's law of constant heat summation, enthalpy of bond dissociation, combustion, formation, atomization, sublimation, phase transition, ionization, solution and dilution.

**Second law of Thermodynamics -** (brief introduction), Introduction of entropy as a state function, Gibb's energy change for spontaneous and non- spontaneous processes, criteria for equilibrium,

**Third law of thermodynamics** (brief introduction).

**The Gaseous State -** Qualitative treatment of Gas laws, Ideal gas equation and deviations from it.

### Unit 6: Equilibrium

Equilibrium in physical and chemical processes, dynamic nature of equilibrium, law of mass action, equilibrium constant, factors affecting equilibrium – Le Chatelier's principle, ionic equilibrium- ionization of acids and bases, strong and weak electrolytes, degree of ionization, ionization of poly basic acids, acid strength, concept of pH, hydrolysis of salts (elementary idea), buffer solution, Henderson Equation, solubility product, common ion effect (with illustrative examples).

## Unit 7: Redox Reactions

Concept of oxidation and reduction, redox reactions, oxidation number, balancing redox reactions, in terms of loss and gain of electrons and change in oxidation number, applications of redox reactions.

## Unit 8: Organic Chemistry – Some Basic Principles and Techniques

General introduction, methods of purification, qualitative and quantitative analysis, classification and IUPAC nomenclature of organic compounds. Electronic displacements in a covalent bond: inductive effect, electrometric effect, resonance and hyper conjugation. Homolytic and heterolytic fission of a covalent bond: free radicals, carbocations, carbanions, electrophiles and nucleophiles, types of organic reactions.

## Unit 9: Hydrocarbons

### Aliphatic Hydrocarbons

**Alkanes -** Nomenclature, isomerism, conformation (ethane only), physical properties, chemical reactions including free radical mechanism of halogenation, combustion and pyrolysis.

**Alkenes -** Nomenclature, structure of double bond (ethene), geometrical isomerism, physical properties, methods of preparation, chemical reactions: addition of hydrogen, halogen, water, hydrogen halides (Markovnikov's addition and peroxide effect), ozonolysis, oxidation, mechanism of electrophilic addition.

**Alkynes -** Nomenclature, structure of triple bond (ethyne), physical properties, methods of preparation, chemical reactions: acidic character of alkynes, addition reaction of - hydrogen, halogens, hydrogen halides and water.

### Aromatic Hydrocarbons

Introduction, IUPAC nomenclature, benzene: resonance, aromaticity, chemical properties: mechanism of electrophilic substitution. Nitration, sulphonation, halogenation, Friedel Craft's alkylation and acylation, directive influence of functional group in mono substituted benzene, carcinogenicity and toxicity

## CLASS XII - THEORY

| Unit | Title |
|------|-------|
| 1 | Solutions |
| 2 | Electrochemistry |
| 3 | Chemical Kinetics |
| 4 | d -and f -Block Elements |

| 5 | Coordination Compounds |
|---|---|
| 6 | Haloalkanes and Haloarenes |
| 7 | Alcohols, Phenols and Ethers |
| 8 | Aldehydes, Ketones and Carboxylic Acids |
| 9 | Amines |
| 10 | Biomolecules |

## Unit 1: Solutions

Types of solutions, expression of concentration of solutions of solids in liquids, solubility of gases in liquids, solid solutions, Raoult's law, colligative properties - relative lowering of vapor pressure, elevation of boiling point, depression of freezing point, osmotic pressure, determination of molecular masses using colligative properties, abnormal molecular mass, Van't Hoff factor

## Unit 2: Electrochemistry

Redox reactions, EMF of a cell, standard electrode potential, Nernst equation and its application to chemical cells, Relation between Gibbs energy change and EMF of a cell, conductance in electrolytic solutions, specific and molar conductivity, variations of conductivity with concentration, Kohlrausch's Law, electrolysis and law of electrolysis (elementary idea), dry cell-electrolytic cells and Galvanic cells, lead accumulator, fuel cells, corrosion.

## Unit 3: Chemical Kinetics

Rate of a reaction (Average and instantaneous), factors affecting rate of reaction: concentration, temperature, catalyst; order and molecularity of a reaction, rate law and specific rate constant, integrated rate equations and half-life (only for zero and first order reactions), concept of collision theory (elementary idea, no mathematical treatment), activation energy, Arrhenius equation.

## Unit 4: d and f Block Elements

General introduction, electronic configuration, occurrence and characteristics of transition metals, general trends in properties of the first row transition metals – metallic character, ionization enthalpy, oxidation states, ionic radii, colour, catalytic property, magnetic properties, interstitial compounds, alloy formation, preparation and properties of $K_2Cr_2O_7$ and $KMnO_4$.

**Lanthanides -** Electronic configuration, oxidation states, chemical reactivity and lanthanide contraction and its consequences.

**Actinides -** Electronic configuration, oxidation states and comparison with lanthanides.

## Unit 5: Coordination Compounds

**Coordination compounds** - Introduction, ligands, coordination number, colour, magnetic properties and shapes, IUPAC nomenclature of mononuclear coordination compounds. Bonding, Werner's theory, VBT, and CFT; structure and stereoisomerism, importance of coordination compounds (in qualitative analysis, extraction of metals and biological system).

## Unit 6: Haloalkanes and Haloarenes

**Haloalkanes:** Nomenclature, nature of C–X bond, physical and chemical properties, optical rotation mechanism of substitution reactions.
**Haloarenes:** Nature of C–X bond, substitution reactions (Directive influence of halogen in monosubstituted compounds only).
Uses and environmental effects of - dichloromethane, trichloromethane, tetrachloromethane, iodoform, freons, DDT.

## Unit 7: Alcohols, Phenols and Ethers

**Alcohols:** Nomenclature, methods of preparation, physical and chemical properties (of primary alcohols only), identification of primary, secondary and tertiary alcohols, mechanism of dehydration, uses with special reference to methanol and ethanol. **Phenols:** Nomenclature, methods of preparation, physical and chemical properties, acidic nature of phenol, electrophilic substitution reactions, uses of phenols.
**Ethers:** Nomenclature, methods of preparation, physical and chemical properties, uses

## Unit 8: Aldehydes, Ketones and Carboxylic Acids

**Aldehydes and Ketones:** Nomenclature, nature of carbonyl group, methods of preparation, physical and chemical properties, mechanism of nucleophilic addition, reactivity of alpha hydrogen in aldehydes, uses.
**Carboxylic Acids:** Nomenclature, acidic nature, methods of preparation, physical and chemical properties; uses.

## Unit 9: Amines

**Amines:** Nomenclature, classification, structure, methods of preparation, physical and chemical properties, uses, identification of primary, secondary and tertiary amines. **Diazonium salts:** Preparation, chemical reactions and importance in synthetic organic chemistry.

## Unit 10: Biomolecules

**Carbohydrates -** Classification (aldoses and ketoses), monosaccharides (glucose and fructose), D-L configuration oligosaccharides (sucrose, lactose, maltose), polysaccharides (starch, cellulose, glycogen); Importance of carbohydrates.

**Proteins -** Elementary idea of - amino acids, peptide bond, polypeptides, proteins, structure of proteins - primary, secondary, tertiary structure and quaternary structures (qualitative idea only), denaturation of proteins; enzymes. Hormones - Elementary idea excluding structure.

**Vitamins -** Classification and functions.

**Nucleic Acids:** DNA and RNA.

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### CLASS XI - THEORY

| Unit | Title |
|------|-------|
| I. | Sets and Functions |
| II. | Algebra |
| III. | Coordinate Geometry |
| IV. | Calculus |
| V. | Statistics and Probability |

**Unit-I: Sets and Functions**

**1.1.    Sets**

Sets and their representations, Empty set, Finite and Infinite sets, Equal sets, Subsets, Subsets of a set of real numbers especially intervals (with notations). Universal set. Venn diagrams. Union and Intersection of sets. Difference of sets. Complement of a set. Properties of Complement. Practical problems on Union and Intersection of two sets.

**1.2.    Relations & Functions**

Ordered pairs. Cartesian product of sets. Number of elements in the Cartesian product of two finite sets. Cartesian product of the set of reals with itself (up to R x R x R). Definition of relation, pictorial diagrams, domain, co-domain and range of a relation. Function as a special type of relation. Pictorial representation of a function, domain, co-domain and range of a function. Real valued functions, domain and range of these functions, constant, identity, polynomial, rational, modulus, signum, exponential, logarithmic and greatest integer functions, with their graphs. Sum, difference, product and quotients of functions. Composition of Functions

**1.3.    Trigonometric Functions**

Positive and negative angles. Measuring angles in radians and in degrees and conversion from one measure to another. Definition of trigonometric functions with the help of unit circle. Truth of the identity $sin^2x + cos^2x = 1$, for all x. Signs of trigonometric functions. Domain and range of trigonometric functions and their graphs. Expressing

$sin (x \pm y)$ and $cos (x \pm y)$ in terms of $sinx$, $siny$, $cosx$ & $cosy$ and their simple applications. Deducing identities like the following:

$$\tan(x \pm y) = \frac{\tan x \pm \tan y}{1 \mp \tan x \tan y}, \cot(x \pm y) = \frac{\cot x \mp \cot y}{\cot y \pm \cot x}$$

$$\sin \alpha \pm \sin \beta = 2 \sin\frac{1}{2}(\alpha \pm \beta) \cos\frac{1}{2}(\alpha \mp \beta)$$

$$\cos \alpha + \cos \beta = 2 \cos\frac{1}{2}(\alpha + \beta) \cos\frac{1}{2}(\alpha - \beta)$$

$$\cos \alpha - \cos \beta = -2 \sin\frac{1}{2}(\alpha + \beta) \sin\frac{1}{2}(\alpha - \beta)$$

Identities related to $\sin 2x$, $\cos 2x$, $\tan 2x$, $\sin 3x$, $\cos 3x$ and $\tan 3x$. General solution of trigonometric equations of the type $\sin y = \sin a$, $\cos y = \cos a$ and $\tan y = \tan a$.

**Unit-II: Algebra**

**2.1.    Principle of Mathematical Induction**

 Process of the proof by induction, motivating the application of the method by looking at natural numbers as the least inductive subset of real numbers. The principle of mathematical induction and simple applications.

**2.2.    Complex Numbers and Quadratic Equations**

Need for complex numbers, especially $\sqrt{-1}$, to be motivated by inability to solve some of the quadratic equations. Algebraic properties of complex numbers. Argand plane. Polar representation of complex numbers. Statement of Fundamental Theorem of Algebra, solution of quadratic equations (with real coefficients) in the complex number system.

**2.3.    Linear Inequalities**

Linear inequalities. Algebraic solutions of linear inequalities in one variable and their representation on the number line. Graphical solution of linear inequalities in two variables. Graphical method of finding a solution of system of linear inequalities in two variables.

**2.4.    Permutations and Combinations**

Fundamental principle of counting. Factorial $n$. (n!) Permutations and combinations, derivation of Formulae for $^nP_r$, $^nC_r$ and their connections, simple applications.

### 2.5.  Binomial Theorem

Historical perspective, statement and proof of the binomial theorem for positive integral indices.

Pascal's triangle, simple applications. General and middle term in binomial expansion.

### 2.6.  Sequence and Series

Sequence and Series. Arithmetic Mean (A.M.) Geometric Progression (G.P.), general term of a G.P., sum of $n$ terms of a G.P., infinite G.P. and its sum, geometric mean (G.M.), relation between A.M. and G.M
Formulae for the following special sums

$$\sum_{k=1}^{n} k \, , \sum_{k=1}^{n} k^2 \, , \sum_{k=1}^{n} k^3$$

## Unit-III: Coordinate Geometry

### 3.1.  Straight Lines

Brief recall of two-dimensional geometry from earlier classes. Slope of a line and angle between two lines. Various forms of equations of a line: parallel to axis, point -slope form, slope-intercept form, two-point form, intercept form. Distance of a point from a line. Normal form. General equation of a line.

### 3.2.  Conic Sections

Sections of a cone: circles, ellipse, parabola, hyperbola, a point, a straight line and a pair of intersecting lines as a degenerated case of a conic section. Standard equations and simple properties of parabola, ellipse and hyperbola. Standard equation of a circle.

### 3.3. Introduction to Three-dimensional Geometry

Coordinate axes and coordinate planes in three dimensions. Coordinates of a point.

Distance between two points. Section formula.

## Unit-IV: Calculus

### 4.1. Limits and Derivatives

Derivative introduced as rate of change both as that of distance function and geometrically. Intuitive idea of limit. Limits of polynomials and rational functions trigonometric, exponential and logarithmic functions. Definition of derivative relate it to scope of tangent of the curve, derivative of sum, difference, product and quotient of functions of polynomial and trigonometric functions. Derivatives of composite functions (Chain rule).

## Unit-V Statistics and Probability

### 5.1. Statistics

Measures of Dispersion: Range, Mean deviation, variance and standard deviation of ungrouped/grouped data.

### 5.2. Probability

Events; occurrence of events, 'not', 'and' and 'or' events, exhaustive events, mutually exclusive events, Axiomatic (set theoretic) probability, connections with other theories of earlier classes. Probability of an event, probability of 'not', 'and' and 'or' events. Random experiments; outcomes, sample space (set representation).

## CLASS XII - THEORY

| Unit | Title |
|------|-------|
| I. | Relations and Functions |
| II. | Algebra |
| III. | Calculus |
| IV. | Vectors and Three - Dimensional Geometry |
| V. | Linear Programming |
| VI. | Probability |

## Unit-I: Relations and Functions

## 1.1. Relations and Functions

Types of relations: reflexive, symmetric, transitive and equivalence relations. One to one and onto functions.

## 1.2. Inverse Trigonometric Functions

Definition, range, domain, principal value branch. Graphs of inverse trigonometric functions.

## Unit-II: Algebra

## 2.1. Matrices

Concept, notation, order, equality, types of matrices, zero and identity matrix, transpose of a matrix, symmetric and skew symmetric matrices. Operations on matrices: Addition and multiplication and multiplication with a scalar. Simple properties of addition, multiplication and scalar multiplication. Non- commutativity of multiplication of matrices and existence of nonzero matrices whose product is the zero matrix (restrict to square matrices of order 2). Invertible matrices and proof of the uniqueness of inverse, if it exists; (Here all matrices will have real entries).

## 2.2. Determinants

Determinant of a square matrix (up to 3 x 3 matrices), minors, co-factors and applications of determinants in finding the area of a triangle. Adjoint and inverse of a square matrix. Consistency, inconsistency and number of solutions of system of linear equations by examples, solving system of linear equations in two or three variables (having unique solution) using inverse of a matrix.

## Unit-III: Calculus

## 3.1. Continuity and Differentiability

Continuity and differentiability, chain rule, derivative of composite functions, derivatives of inverse trigonometric functions like $\sin^{-1} x$, $\cos^{-1} x$ and $\tan^{-1} x$, derivative of implicit functions. Concept of exponential and logarithmic functions. Derivatives of logarithmic and exponential functions. Logarithmic differentiation, derivative of functions expressed in parametric forms. Second order derivatives.

## 3.2. Applications of Derivatives

Applications of derivatives: rate of change of quantities, increasing/decreasing functions, maxima and minima (first derivative test motivated geometrically and second derivative test given as a provable tool). Simple problems (that illustrate basic principles and understanding of the subject as well as real- life situations).

### 3.3. Integrals

Integration as inverse process of differentiation. Integration of a variety of functions by substitution, by partial fractions and by parts, Evaluation of simple integrals of the following types and problems based on them.

$$\int \frac{dx}{x^2 \pm a^2}, \int \frac{dx}{\sqrt{x^2 \pm a^2}}, \int \frac{dx}{\sqrt{a^2 - x^2}}, \int \frac{dx}{ax^2 + bx + c}, \int \frac{dx}{\sqrt{ax^2 + bx + c}}, \int \frac{px + q}{ax^2 + bx + c} dx,$$

$$\int \frac{px + q}{\sqrt{ax^2 + bx + c}} dx, \int \sqrt{a^2 \pm x^2} \, dx, \int \sqrt{x^2 - a^2} \, dx, \int \sqrt{ax^2 + bx + c} \, dx$$

Fundamental Theorem of Calculus (without proof). Basic properties of definite integrals and evaluation of definite integrals.

### 3.4. Application of the Integrals

Applications in finding the area under simple curves, especially lines, circles/ parabolas/ellipses (in standard form only)

### 3.5. Differential Equations

Definition, order and degree, general and particular solutions of a differential equation. Solution of differential equations by method of separation of variables, solutions of homogeneous differential equations of first order and first degree. Solutions of linear differential equation of the type:

$\frac{dy}{dx} + py = q$, where $p$ and $q$ are functions of $x$ or constants.

$\frac{dx}{dy} + px = q$, where $p$ and $q$ are functions of $y$ or constants.

## Unit-IV: Vectors and Three-dimensional Geometry

### 4.1. Vectors

Vectors and scalars, magnitude and direction of a vector. Direction cosines and direction ratios of a vector. Types of vectors (equal, unit, zero, parallel and collinear vectors), position vector of a point, negative of a vector, components of a vector, addition of vectors, multiplication of a vector by a scalar, position vector of a point dividing a line segment in a given ratio. Definition, Geometrical Interpretation, properties and application of scalar (dot) product of vectors, vector (cross) product of vectors.

### 4.2. Three-dimensional Geometry

Direction cosines and direction ratios of a line joining two points. Cartesian equation and vector equation of a line, skew lines, shortest distance between two lines. Angle between two lines.

### Unit-V: Linear Programming Problem

#### 5.1.  Linear Programming

Introduction, related terminology such as constraints, objective function, optimization, graphical method of solution for problems in two variables, feasible and infeasible regions (bounded or unbounded), feasible and infeasible solutions, optimal feasible solutions (up to three non-trivial constraints).

### Unit-VI: Probability

#### 5.2.  Probability

Conditional probability, multiplication theorem on probability, independent events, total probability, Bayes' theorem.

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## CLASS XI – THEORY

### 1: Units and Measurements

Units of measurement ; Systems of units ; SI units ; Fundamental and derived units ; Significant figures ; Dimensions of physical quantities ; Dimensional analysis and its applications.

### 2: Motion in a Straight Line

Frame of reference ; Motion in a straight line ; Uniform and non- uniform motion ; Average speed and average velocity and instantaneous velocity ; Uniformly accelerated motion ; Graphical representation of rectilinear motion ; Kinematic relations for uniformly accelerated motion

### 3: Motion in a Plane

Scalar and vector quantities to describe planar motion ; Unit vectors ; Addition and subtraction of vectors, Resolution of vectors into rectangular components in a plane ; Scalar and Vector product of two vectors.
Motion in a plane with uniform acceleration ; projectile motion ; uniform circular motion.

### 4: Laws of Motion

Concept of inertia and Newton's first law of motion ; Concept of momentum and Newton's second law of motion ; Impulse ; Newton's third law of motion.

Law of conservation of linear momentum and its applications.

Equilibrium of concurrent forces ; Static and kinetic friction, laws of friction, rolling friction, lubrication.

Dynamics of uniform circular motion: Centripetal and centrifugal forces, common examples of circular motion.

### 5: Work, Energy and Power

Work done by a constant force and a variable force; kinetic energy, work- energy theorem, power.

Notion of potential energy, example of a spring ; Conservative and non-conservative forces ; Motion in a vertical circle ; Elastic and inelastic collisions in one and two dimensions.

### 6: Rigid System of Particles and Rotational Motion

Centre of mass of a system of particles ; momentum conservation and Centre of mass motion.

Moment of a force, torque, angular momentum, law of conservation of angular momentum and its applications.

Equilibrium of a rigid body ; Moment of inertia, radius of gyration, moments of inertia for simple geometrical objects.

Comparison of linear and rotational motions.

### 7: Gravitation

Kepler's laws of planetary motion ; Universal law of gravitation.
Acceleration due to gravity and its variation with altitude and depth.
Gravitational potential energy ; Escape speed ; Orbital velocity and energy of an orbiting satellite.

### 8: Mechanical Properties of Solids

Elasticity ; Stress-strain relationship ; Hooke's law ; Young's modulus, bulk modulus, concept of shear modulus of rigidity, Poisson's ratio ; Elastic energy ; Application of elastic behavior of materials (qualitative idea only).

### 9: Mechanical Properties of Fluids

Pressure due to a fluid column; Pascal's law and its applications (hydraulic lift and hydraulic brakes), effect of gravity on fluid pressure ;
Viscosity : Stokes' law, terminal velocity, streamline and turbulent flow, critical velocity, Bernoulli's theorem and its simple applications (Torricelli's law and Dynamic lift) ;

Surface energy and surface tension, angle of contact, excess of pressure across a curved surface, application of surface tension in understanding droplets, bubbles and capillary rise.

### 10: Thermal Properties of Matter

Heat, temperature, thermal expansion of solids, liquids and gases ; anomalous expansion of water ; specific heat capacity : $C_p$, $C_v$ – calorimetry ; change of state - latent heat capacity

Heat transfer : conduction, convection and radiation, thermal conductivity, qualitative ideas of Blackbody radiation :  Wein's displacement Law , Stefan's law ; Newton's law of cooling.

## 11: Thermodynamics

Thermal equilibrium ; zeroth law of thermodynamics ; Heat, work and internal energy;

First law of thermodynamics ; Thermodynamic state variable and equation of state ;

Thermodynamic processes : isothermal, adiabatic, reversible, irreversible, and cyclic processes ; Second law of thermodynamics ; Carnot engine.

## 12: Kinetic Theory of gases

Equation of state of ideal gas, work done in compressing a gas.

Kinetic theory of an ideal gas - assumptions, concept of pressure ; Kinetic interpretation of temperature ; rms speed of gas molecules ; degrees of freedom, law of equi-partition of energy (statement only) and application to specific heat capacities of gases ; concept of mean free path ; Avogadro's number.

## 13: Oscillations

Periodic motion - time period, frequency, displacement as a function of time, periodic functions and their applications.
Simple harmonic motion (S.H.M) : velocity, acceleration ; uniform circular motion and its equations of motion ; Concept of phase ; Energy in S.H.M. :, kinetic and potential energies ; Simple pendulum : derivation of expression for its time period ; Oscillations of a loaded spring.

## 14: Waves

Wave motion: Transverse and longitudinal waves ; speed of a traveling wave ; displacement relation for a progressive wave ; principle of superposition of waves ; reflection of waves ; standing waves in strings and organ pipes, fundamental mode and harmonics ; Beats.

## CLASS XII – THEORY

### 1: Electric Charges and Fields

Electric charges ; Conductors and Insulators ; Coulomb's law - force between two- point charges, forces between multiple charges ; superposition principle and continuous charge distribution

Electric field, electric field lines, electric dipole, electric field due to a dipole, torque on a dipole in uniform electric field ;

Electric flux, statement of Gauss's theorem and its applications to find field due to charged objects ;

## 2: Electrostatic Potential and Capacitance

Electric potential, potential difference ; electric potential due to : a point charge, a dipole and system of charges ; Equipotential surfaces ; electrical potential energy of a system of charges and electric dipole in electrostatic field.

Conductors and insulators ; Electrostatics of conductor ;

Dielectrics and electric polarization ; Capacitors and capacitance, combination of capacitors in series and in parallel, capacitance of a parallel plate capacitor with and without dielectric medium between the plates, energy stored in a capacitor

## 3: Current Electricity

Electric current : flow of electric charges in a metallic conductor ; drift velocity, mobility and their relation with electric current ; Ohm's law ; V-I characteristics (linear and non-linear) ; electrical energy and power ; electrical resistivity and conductivity ; temperature dependence of resistance ; Cells : Internal resistance, potential difference and emf, combination of cells in series and in parallel ; Kirchhoff's rules ; Wheatstone bridge.

## 4: Moving Charges and Magnetism

Concept of magnetic field ; Oersted's experiment ; Biot - Savart law and its application ; Ampere's law and its applications; Straight solenoid ; Force on a moving charge in uniform magnetic and electric fields.

Force on a current-carrying conductor in a uniform magnetic field, force between two parallel current-carrying conductors-definition of ampere ; Torque experienced by a current loop in uniform magnetic field ; Current loop as a magnetic dipole and its magnetic dipole moment ; Moving coil galvanometer- its current sensitivity and conversion to ammeter and voltmeter.

## 5: Magnetism and Matter

Bar magnet ; Magnetism and Gauss's Law ; Magnetisation and Magnetic Intensity ; Torque on a magnetic dipole (bar magnet) in a uniform magnetic field, Magnetic field lines.

Magnetic properties of materials- Para-, dia- and ferro- magnetic substances ;
Effect of temperature on magnetic properties.

### 6: Electromagnetic Induction

Electromagnetic induction ; Faraday's laws, induced EMF and current ; Lenz's Law, Self and mutual induction.

### 7: Alternating Current

Alternating currents, peak and RMS value of alternating current/voltage; Representation of AC current and voltage by rotating Vectors — Phasors ; AC voltage applied to resistor(R), inductor(L), capacitor(C) ; reactance and impedance ; AC current and voltage in LR, LC, LCR series circuits ; Resonance ; Power in AC circuits, power factor, wattless current. AC generator, Transformer.

### 8: Electromagnetic Waves

Displacement current, Electromagnetic waves.

Electromagnetic spectrum : Elementary facts (frequency range, sources and use) about radio waves, microwaves, infrared, visible, ultraviolet, X-rays, gamma rays.

### 9: Ray Optics

Reflection of light, spherical mirrors, mirror formula ; Refraction of light, total internal reflection and optical fibers, refraction at spherical surfaces, lenses, thin lens formula, lens maker's formula, magnification, power of a lens, combination of thin lenses in contact ; Refraction of light through a prism.

### 10: Wave Optics

Wave front and Huygen's principle : Reflection and refraction of plane wave at a plane surface using wave fronts, Proof of laws of reflection and refraction using Huygen's principle ; Interference : Young's double slit experiment, coherent sources and sustained interference of light, diffraction due to a single slit.

### 11: Dual Nature of Radiation and Matter

Dual nature of radiation ; Photoelectric effect, Hertz and Lenard's observations ;
Einstein's photoelectric equation : energy quantum of radiation ;
Experimental study of photoelectric effect ;
Wave nature of particles : de-Broglie relation.

**12: Atoms**

Alpha-particle scattering experiment; Rutherford's model of atom; Bohr model of hydrogen atom, Expression for radius of nth possible orbit, velocity and energy of electron in nth orbit, hydrogen line spectra.

**13: Nuclei**

Atomic masses and composition and size of nucleus ; nuclear force ;

Mass-energy relation, mass defect ; binding energy per nucleon and its variation with mass number; nuclear fission, nuclear fusion.

**14: Semiconductor Electronics: Materials, Devices and Simple Circuits**

Classification of Metals, Conductors and Semiconductors ;
Intrinsic and extrinsic semiconductors- p and n type, p-n junction ;
Semiconductor diode - I-V characteristics in forward and reverse bias, application of junction diode -diode as a rectifier.

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# SYLLABUS